ACOUSTIC EMISSION TEST FOR SLOPE MONITORING

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ABSTRACT

The stability forecasting of rock slope is more difficult than soil slope because catching the sign of failure in monitoring is not easy and deformation of the rock is small in failure process. But in the rock slope, there is small deformation like crack propagation in rock itself and it accumulates gradually in failure process. If it is possible to detect the small change in the rock slope, we can know the failure time exactly.

Because monitoring of the acoustic emission catches the individual signal, it is possible to monitoring the slope if many sound signal is accumulated.

Detection test of acoustic emission was performed. Uniaxial, two types of bending test were done with 26 cement paste sample. Wave propagation velocity of uniaxial test sample was increased with curing time. And we can get the AE wave form and frequency. Analysis give us the result that there is a AE sign signal before the failure, the AE count is suddenly increased. And frequency level 125kHz before failure is changed to level 200-250kHz after failure.

The result of this study can be used in the application of acoustic emission in rock slope monitoring to detect the sign before failure.

1. INTRODUCTION

The stability forecasting of rock slope is more difficult than soil slope because catching the sign of failure in monitoring is not easy and deformation of the rock is small in failure process. But in the rock slope, there is small deformation like crack propagation in

rock itself and it accumulates gradually in failure process. If it is possible to detect the small change in the rock slope, we can know the failure time exactly. Because monitoring of the acoustic emission catches the individual signal, it is possible to monitoring the slope if many sound signals are accumulated.

Detection test of acoustic emission was conducted. Uniaxial, two types of bending test were done with 26 cement paste sample. Wave propagation velocity of uniaxial test sample was increased with curing time. In this study we develop the foreseeing the slope failure method using acoustic emission detection in slope. The laboratory test is conducted for basic data of acoustic emission to use AE in slope monitoring. For this we conduct the uniaxial, bending test using cylinder, rectangular beam shaped samples.

2. Acoustic Emission

2.1 Basic theory

Because of the progress of acoustic emission detecting and recording device, efficient monitoring and analysis can be possible using the acquired signal and converted variables from that signal.

Acoustic emission variables are AE count, amplitude, duration, rise time, AE energy and definition is explained below. Fig 1. shows the definition of the AE variables.

(1) AE count : refers to the number of pulses emitted by the measurement circuitry if the signal amplitude is greater than the threshold. Depending on the magnitude of the AE event and the characteristics of the material, one hit may produce one or many counts. While this is a relatively simple parameter to collect, it usually needs to be combined with amplitude and/or duration measurements to provide quality information about the shape of a signal.

(2) Amplitude : is the greatest measured voltage in a waveform and is measured in decibels (dB). This is an important parameter in acoustic emission inspection because it determines the detectability of the signal. Signals with amplitudes below the operator-defined, minimum threshold will not be recorded.

(3) Duration : is the time difference between the first and last threshold crossings. Duration can be used to identify different types of sources and to filter out noise. Like counts (N), this parameter relies upon the magnitude of the signal and the acoustics of the material.

(4) Rise time : is the time interval between the first threshold crossing and the signal peak. This parameter is related to the propagation of the wave between the source of the acoustic emission event and the sensor. Therefore, rise time is used for qualification of signals and as a criterion for noise filter.

(5) AE energy : is the measure of the area under the envelope of the wave signal from the transducer

Shiotani(2001) made the system that monitors the AE signal of breaking grout material which generated when slope discontinuity failed, transformed along the steel bar. Fig. 2 shows that system. In this study, grout material samples were made for the basic study of acoustic emission like Shiotani's study.

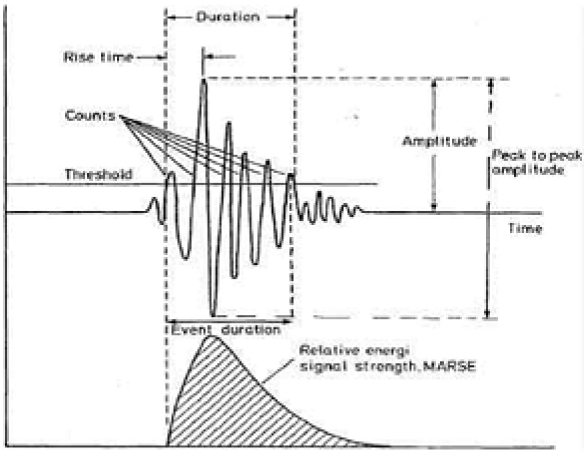

Fig. 1 Acoustic emission features

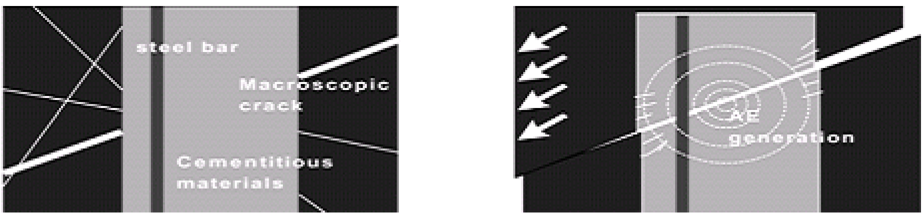

Fig. 2 Basic concept of acoustic emission measurement(Shiotani(2001)

2.2 Sample preparation

Uniaxial test samples are 100mm diameter and cylindrical shape, bending test samples are two types, beam shape 150×150×550mm size and cylindrical shape, 100mm diameter, steel bar inserted. These samples have water cement content ratio 1:1. Fig 3 shows these samples in curing and fig 4 shows experiment samples after curing.

Fig. 3 Experiment samples in curing

Fig. 4 Experiment samples

2.3 Equipments

MTS material testing system and MISTRAS AE measuring system made by PAC(Physical Acoustic Corporation) was used in this study. 6 wide range AE sensors are used for uniaxial test, 4 for bending test.

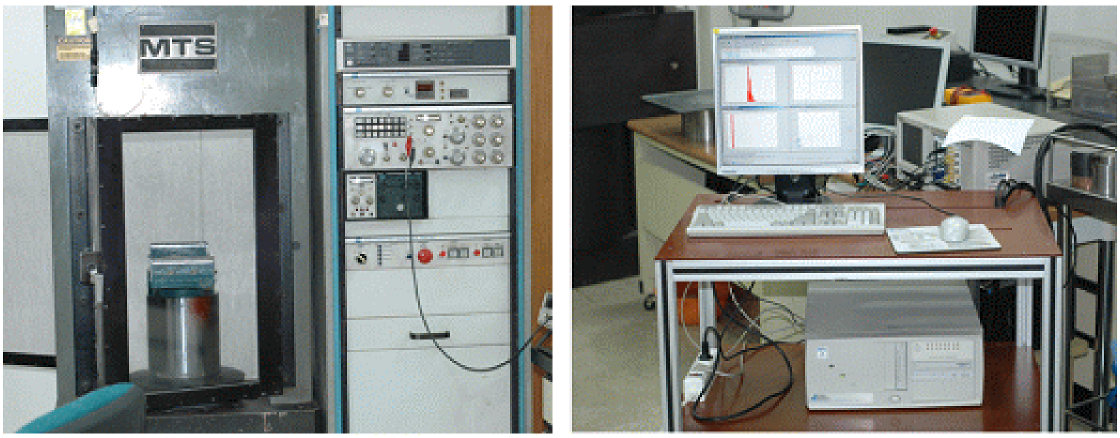

Fig. 5 Material testing machine and A.E measuring equipment

2.4 Test results

2.4.1 Seismic Wave Velocity

Seismic wave velocity was measured using uniaxial test samples. 5 samples are measured after 14 days curing, another 5 samples are measured after 28 days curing. Table 1 show the P and S wave velocity for different curing day. Table 1 shows that average P wave velocity of 14 days curing samples is 3940m/sec, average S wave velocity of 14 days curing samples is 2120m/sec, average P wave velocity of 28 days curing samples is 4052m/sec, average S wave velocity of 28 days curing samples is 2133m/sec, small increase for the 28 days curing samples. This result agrees with the fact that the seismic wave velocity is increase with curing day increase.

Table 1 Seismic wave velocity according to curing days

Uniaxial Test	P-wave velocity(m/sec)	S-wave velocity(m/sec)	Curing
U1	3860	2050	14days curing
U2	4170	2260	14days curing
U3	3870	2050	14days curing
U4	3890	2180	14days curing
U5	3930	2070	14days curing
U6	4034	2090	28days curing
U7	4107	2208	28days curing
U8	3985	2098	28days curing
U9	4034	2145	28days curing
U10	4100	2125	28days curing

2.4.2 Uniaxial Test

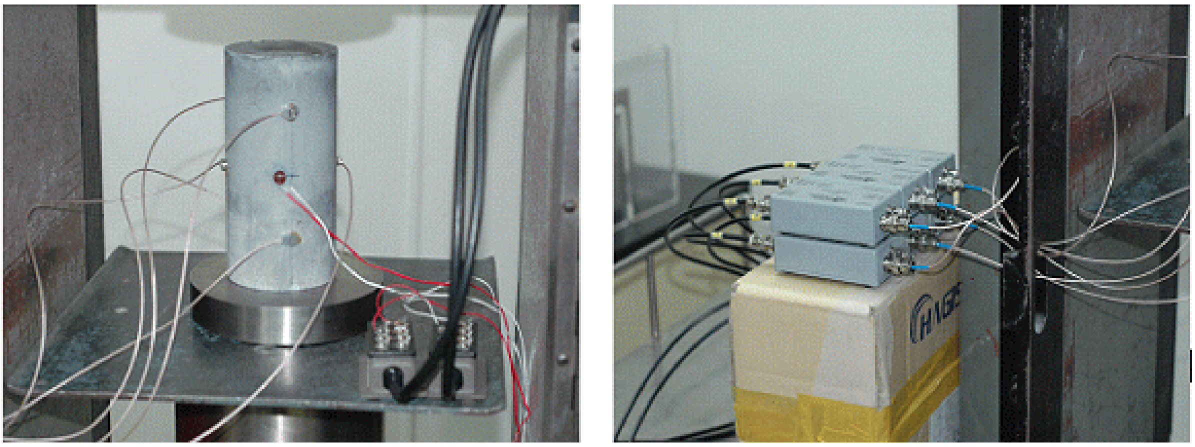

Fig. 6 Uniaxial test sample and pre-amplifier

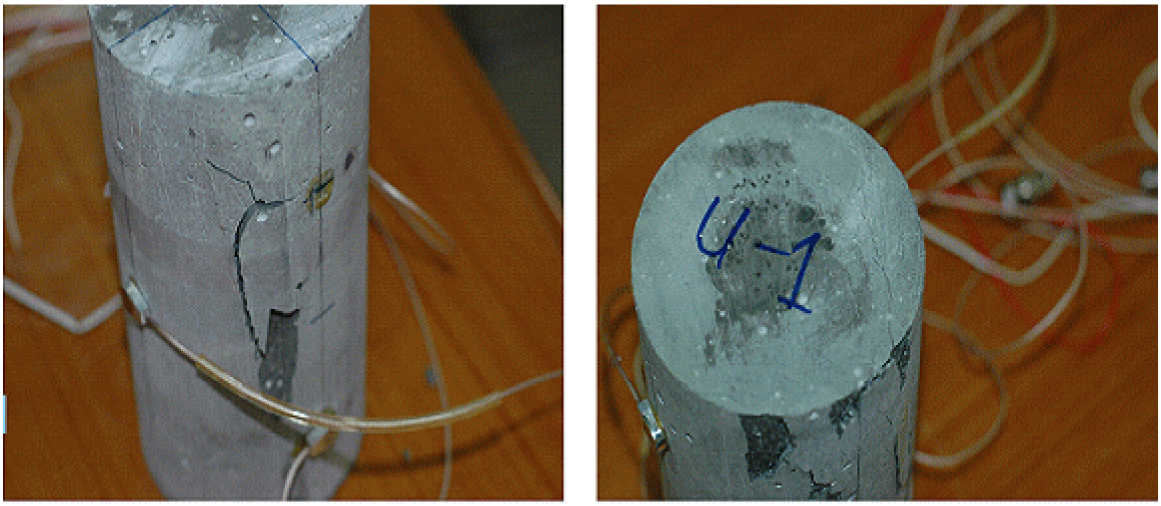

Fig. 7 Uniaxial test sample after failure

Left of fig 6 is the picture of 100mm diameter uniaxial test sample attached by strain gage and 6 wide band sensors, and right of fig 5 is the picture of pre amplifier that is connected to sensor and amplifies the acoustic emission signals.

Fig 7 shows the figure of samples after failure, state of signals from the sensor is general but vertical fracture was shown because of poor surface grinding accuracy. Fig 8 show the variation of AE count versus load as time increase for uniaxial test sample. In this figure we can see the early sign of failure before failure because the load of two samples increase at first but decreased due to the some vertical failures. This is the main feature that we can apply AE to the slope monitoring and more study is needed. The wave of biggest amplitude was generated at this time and the result of

frequency analysis shows that noise signal is around 125kHz but the signal at the failure time is around 200kHz.

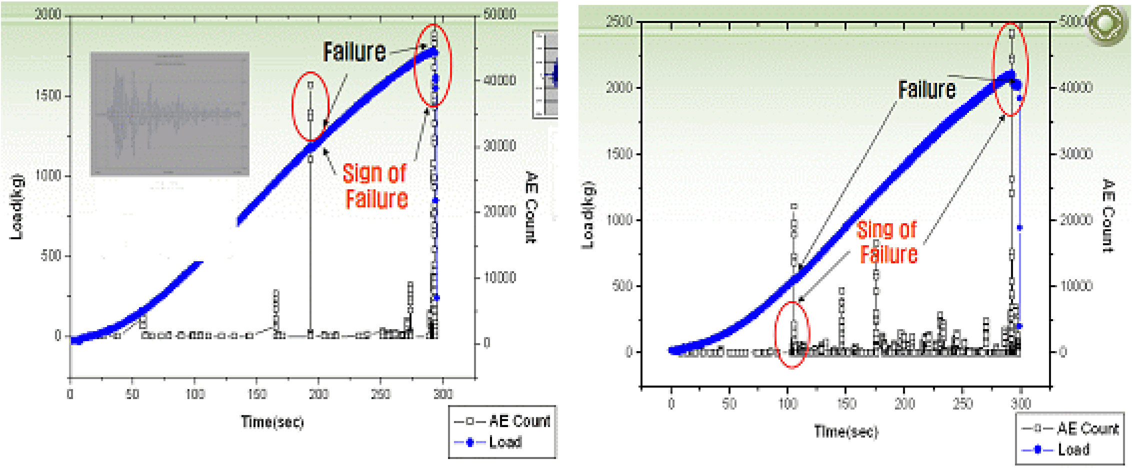

Fig. 8 AE counts and load of uniaxial test samples

2.4.3 Bending Test-Rectangle

Fig. 9 Bending test(rectangle) sample before and after failure

Fig 9 shows the picture of 4 point bending test using beam sample, the failure of the beam initiated at the lower part of center of beam then we attach the sensor around there. 4 wide band sensors are attached 3cm apart from the center lower part of beam. Fig 10. shows the variation of AE count versus load as time increase for bending test sample.

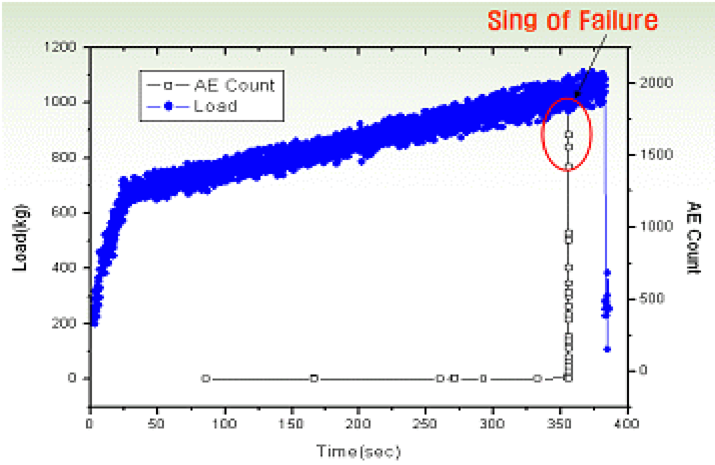

Fig. 10 AE counts and load of bending(rectangle) test sample

2.4.4 Bending Test-Cylinder

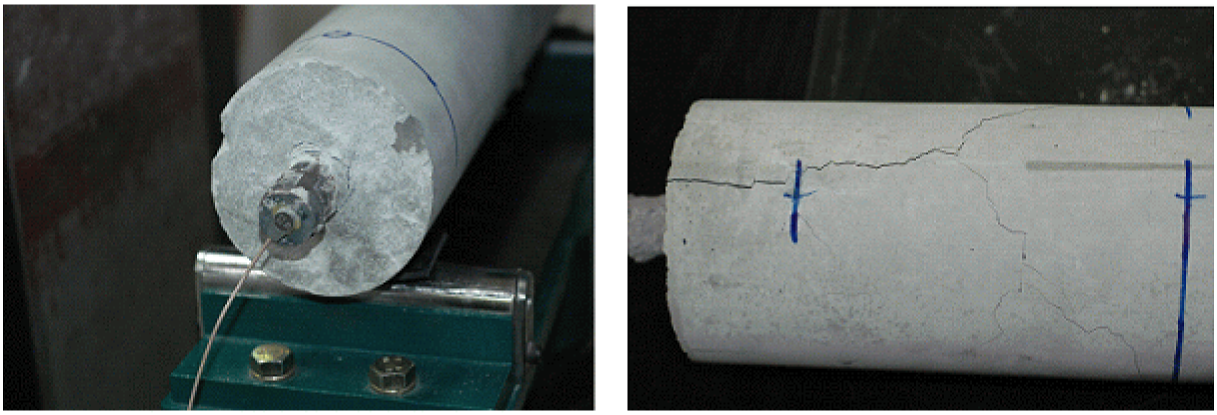

Fig. 11 Bending test(cylinder) sample before and after failure

Fig 11 shows the picture of 4 point bending test using cylinder sample, the failure of the beam initiated at the lower part of center of beam then we attach the sensor around there. 4 wide band sensors are attached 3cm apart from the center lower part of beam. Fig 12. shows abrupt failure of sample but we can see the sign of failure.

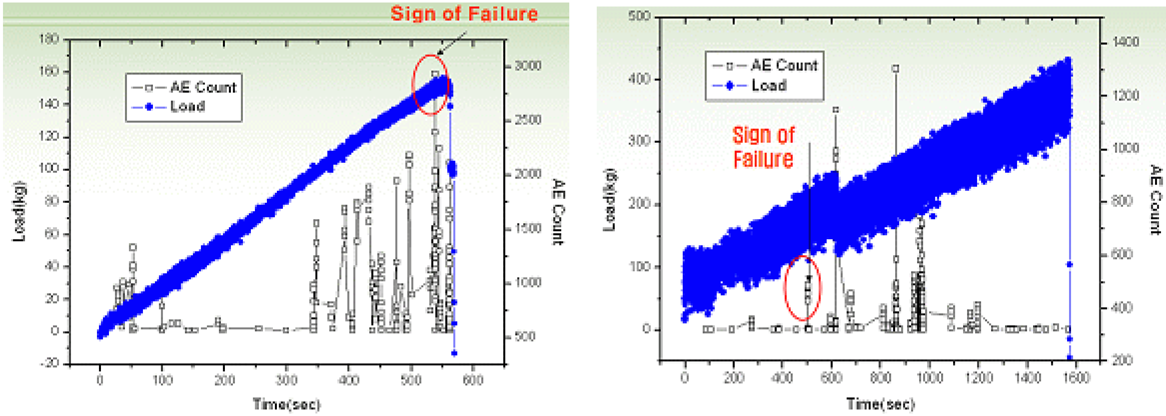

Fig. 12   AE counts and load of bending(cylinder) test sample

3. Conclusion

Detection test of acoustic emission was performed. Uniaxial, two types of bending test were done with 26 cement paste sample. Wave propagation velocity of uniaxial test sample was increased with curing time. And we can get the AE wave form and frequency. Analysis gives us the result that there is AE sign signal before the failure, the AE count is suddenly increased. And frequency level 125kHz before failure is changed to level 200-250kHz after failure.

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Acknowledgement

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Reference

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